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JHK Spectroscopy of the $z = 2.39$ Radio Galaxy 53W002 and Its Companions

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Abstract. We present low-resolution, near-IR JHK spectra of the weak z=2.39 radio galaxy 53W002 and its companion objects #18 and #19, obtained with OHS/CISCO on the Subaru Telescope. They cover rest-frame wavelengths of 3400-7200Å, and many rest-optical emission lines are detected. Contributions to the broad-band flux from these emission lines are found to be very large, up to 40% in the H and K'-bands and 30% in the J-band.

1. Introduction

Recent narrow-band imaging has revealed the existence of a cluster of Lyα emitters around the $z = 2.39$ radio galaxy 53W002 (Pascarelle et al. 1996a,b; Pascarelle et al. 1998; Keel et al. 1999). These emitters have sub-galactic sizes, and are thought to be "building blocks" which will merge into a luminous galaxy at the present epoch.

To investigate the rest-frame optical nature of these objects, we carried out low-dispersion JHK spectroscopy of 53W002, Object #18, and #19 using the newly commissioned instrument of the Subaru telescope, OH-airglow suppression spectrograph (OHS; Iwamuro et al. 2001) and Cooled Infrared Spectrograph and Camera for OHS (CISCO; Motohara et al. 1998).

2. Detection of Strong Rest-Optical Emission Lines

The resulting spectra of these objects are shown in Figure 1. Both 53W002 and Object #18 show very strong [O III] and Hα+[N II] lines. The Balmer jump is also detected in the continuum of 53W002. Object #19, which is known to be a quasar, shows a power-law continuum and a broad (8000 km s^{-1}), strong

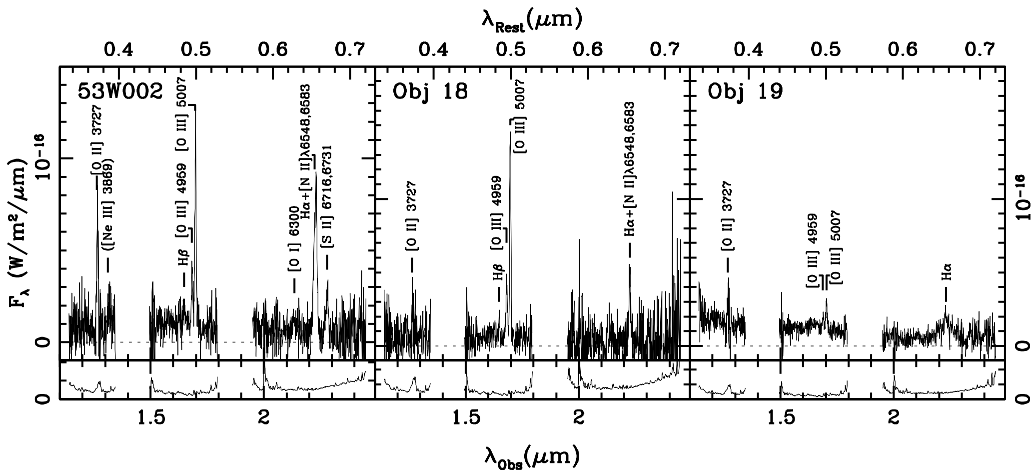

Figure 1. The JHK spectra. Lower box shows the 1σ noise level calculated from the background level.

(3×10^{43} erg s^{-1}; $H_0 = 65$ km s^{-1} Mpc^{-1}, $q_0 = 0.1$) Hα line. The contribution of these lines to the broad-band flux is as high as 45%, as shown in Table 1.

3. Emission Line Diagnosis

Because the wavelength resolution is low ($\lambda/\Delta\lambda = 200 - 400$), we deconvolved the blended Hα+[N II] lines by multiple Gaussian fitting. We then estimated the dust extinction from Hα/Hβ ratio, assuming SMC extinction curve. The estimate of $E(B-V)$ is 0.14 for 53W002 and 0.50 for Object #18.

In Figure 2, two diagrams of reddening corrected emission-line ratios are presented. One show [N II]λ6583/Hα versus [O III]λ5007/Hβ and the other [O II]λ3727/[O III]λ5007 versus [O III]λ5007/Hβ.

We next carried out photoionization calculation using CLOUDY94 (Ferland 2000), and over-plotted the results on Figure 2. These results show that the emission line ratios of 53W002 are well reproduced by a cloud with electron density $n_{\rm e} = 1 \times 10^{3-4}\,{\rm cm}^{-3}$ and solar metallicity, ionized by an $\alpha = -0.7$ power-law continuum. Object #18 seems to be not a star-forming galaxy but a type 2 AGN, and its line ratios are reproduced by a cloud of solar metallicity, ionized by $\alpha = -1.5$ power-law continuum.

Table 1. Contribution of the emission lines to the broad-band flux.

Object	K'	H	J
53W002	42%	30	22
Object #18	32	45	11
Object #19	29	6	4

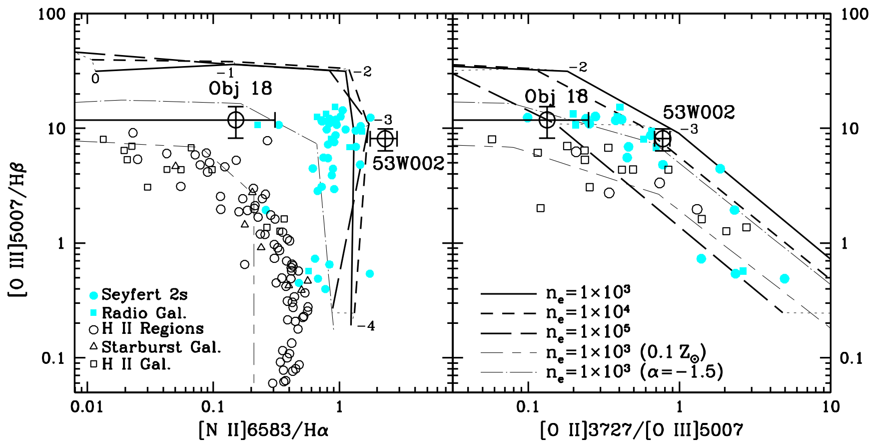

Figure 2. Reddening corrected line ratios of 53W002 and Object #18 (open circles with error bars). Spectral index is assumed to be $\alpha = -0.7$ except for one case of $\alpha = -1.5$ shown by thin dot-dashed line. The metallicity is set to be $Z = 1.0Z_{\odot}$, except for one case of $Z = 0.1Z_{\odot}$ shown by thin dash-long-dashed line. Ionization parameter varies along each curve, and representative points are labeled by their powers.

Both 53W002 and Object #18 show high metallicity (solar abundances). We suggest that they are produced by starburst activity during merger events with surrounding objects, for which we find evidence in our spectrum of 53W002 in the form of the Balmer discontinuity at 4000Å.

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